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ABSTRACT

In order to name an animal they see, children must use their existing mental models to provide the animal with a name. In this study, pupils between the ages of 4 and 14 are presented with preserved specimens of 6 different animals and asked a series of questions about them. The results indicate that pupils of all ages mainly recognize and use anatomical features when naming the animals and explaining why they are what they are. Older students are more likely to use behavioral and habitat attributes and girls are more likely than boys to refer to features of the head, face, and eyes. For both girls and boys, the home and direct observation are more important as sources of knowledge than school or books, though books are more important for boys than girls. As students age their reasons for grouping animals becomes more complicated. (Contains 17 references.) (DDR)

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How do Children See Animals?

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In order to name an animal they see, children use their existing mental models to provide the animal with a name. In this study, pupils of a range of ages (4, 8, 11 and 14 years old) were presented with preserved specimens of six different animals and asked a series of questions about them. The results indicate that pupils of all ages mainly recognise and use anatomical features when naming the animals and explaining why they are what they are. However, older pupils are more likely also to use behavioural and habitat attributes. Girls are more likely than boys to refer to features of the head such as the face, eyes or ears. For both girls and boys, the home and direct observation are more important as sources of knowledge than school or books, though books are more important for boys than for girls. As pupils age, their reasons for grouping animals become more complicated: in addition to relying on shared anatomical features, they begin to show evidence of an embedded taxonomic knowledge, knowing, for instance, what a mammal is and using this knowledge to group animals.

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Building a Model of the Environment: How do Children See Animals?

Theoretical underpinnings

Our work is fuelled by two related interests. First, by the way in which people build mental models, particularly models of the world about them. Secondly, by the understanding school children have of the natural and physical environment. Mental models may be viewed as representations of an object or an event. The process of forming and constructing models is a mental activity of an individual or group (Duit and Glynn 1996). The mental model is the person's personal knowledge of the phenomenon - in the case of the present paper, of selected animals. This personal knowledge will have both similarities to and differences from scientifically accepted knowledge, which in the case of the present paper is such things as the taxonomic position of the animal, its significant morphological features and so on.

The relatively few data that exist suggest that when children view live animals, they identify certain striking features of the organisms. In particular, they mention anatomical features such as the dimensions of the animal, its shape and its colour and comment especially on its front end, on its legs, on other disrupters to its outline and on any unfamiliar organ (Tunnicliffe 1995). These striking features become criterial for children's constructions of animals and become incorporated in their mental models of different kinds of animals. The features of an animal which are criterial for a child can be revealed by obtaining representations by the child of authentic specimens which the child has viewed (Figure 1). These representations may be written descriptions, oral descriptions, drawings or three-dimensional models.

In this study we ask pupils to name and categorise a selection of animals presented to them. As humans, we seem to have a basic need to categorise and name that which is around us (Bruner, Goodnow and Austin 1956, Markman 1989). These activities reflect the order that we seek to impose upon our world. Certainly, visitors to zoos and natural history museums name organisms when they encounter them, thus providing the specimens with an identity to which they can refer. These names seldom identify the organism to the level of a single species, such as 'African elephant', but typically reveal at least the beginnings of a taxonomic understanding. The name 'elephant', for instance, shows that while a visitor may not know that there are two distinct species of elephants [i.e. the African elephant (*Loxodonta africana*) and the Asian elephant (*Elephas maximus*)], he or she recognises the 'elephantness' of the seen specimen and very probably has a simple taxonomy of animals with 'elephant' as a category within animals.

A distinctive view is presented by Gibson (1979) who argues for an 'ecological viewpoint'. Gibson maintains that the environment possesses a correctional structure that is perceived by humans and subsequently used in category construction. This Gibsonian view is relevant to the present study because our methodology involves presenting children with isolated animals, such as a single

armadillo. All animals show adaptations to the environments in which they live. Whether or not pupils identify specimens through matching that which they see with a mental model they hold or observe specimens and recognise features associated with the environment in which the animal lives and thus identify the animal as a member of a certain type of habitat is not known.

A considerable literature exists as to children's understandings of the natural and physical environment (e.g. Strommen 1995, Leach, Driver, Scott and Wood-Robinson 1995) and on what attributes pupils use in their identification and categorisation of animals into the commonly accepted scientific groupings. Ryman (1977) showed that the inability of eleven year old children to classify the exemplars they were given as a member or non-member of a taxonomic group suggests that the children had no grasp of the criterial attributes required to perform such a task. When asked to complete classroom tasks connected with allocating individual animals into given vertebrate groups, children justified their grouping by referring either to a few familiar processes, such as nutrition, respiration reproduction and locomotion, that they associate with the concept 'animal' (Bell 1981, Braund 1991), or to a few salient body parts such as head, limbs, or body covering, as critical attributes for being a group member. Trowbridge and Mintzes (1985) maintain that '... students consider ambiguous and often conflicting pieces of information when classifying animals, ultimately arriving at a decision based on relative size or perceived importance of body parts'. Children notice the salient features of specimens, whether they are live or preserved, and give everyday names to the animals, only categorising when they do not have an appropriate identity which they can allocate (Tunnicliffe 1995).

Comparisons between different populations of children are complicated by the fact that a variety of methodologies have been used. We are keen to provide a methodology and a method of analysis which allows for such inter-population comparisons in addition to comparisons within a population between various pupil categories - e.g. gender and age.

In this paper, our particular aim is to explore how school children aged from five to fourteen years recognise, identify and group animals. We are interested in the relationship between the children's personal knowledge and scientifically accepted knowledge, and in the sources of the children's knowledge which they identify as being of importance to them.

Methods

Fieldwork was carried out in two state schools in the South of England: a Church of England aided primary school (for 5 to 11 year-olds) in a New Town (established after the Second World War) and a secondary comprehensive school (for 11 to 16 year-olds) in a long-established neighbouring town. The same researcher (SDT) carried out all the interviews. The fieldwork was conducted in a separate room (in the secondary school) or in the corner of a classroom (in the primary school). A total of 36 pupils (nine aged 5, nine aged 8, nine aged 10 and nine aged 14) were withdrawn individually from their regular work for the research. Teachers were

asked to ensure that pupils of a range of abilities were interviewed (equal numbers at each age range classified by their teachers as 'above average', 'average' and 'below average').

After completing a pilot study, the six animals listed in table 1 were used. Three of these animals differed from those used in the pilot: the armadillo replaced a red squirrel (so that children now saw one native and one exotic mammal), the stoat replaced a brown rat (brown rats are introduced to the UK and the specimen we had was in rather poor condition) and the crab replaced a starfish (whose shape we decided gave too great a clue as to its name).

Each pupil was shown a group of six animals consisting of single whole, preserved specimens of the six animals listed with their dimensions in table 1. The pupil was first asked to put these animals into the order in which she/he would like to talk about them. This order was recorded and the researcher then presented the animals individually in this order. For each animal in turn the pupil was asked a series of questions about what the animal was (an X), why they had named the animal thus and what made it an X. Finally, they were asked to group the animals, justifying their choice. A photograph illustrating the experimental set up is shown in figure 2.

Questions were asked according to a pre-set format (Appendix A) and prompts used as needed. Pupil answers, and any prompts given by the researcher, were written on observation sheets on which a record was also made of the name, age, sex and ability range (as defined by the teacher) of the pupil (Appendix B). A rationale for the methodology, which we hope will be of use to other researchers, is given in Appendix C.

Results

The order in which pupils choose to talk about the animals

Pupils varied in the time and care they took in deciding the order in which they wished to talk about the animals. Table 2 shows which animals were chosen first by pupils of differing ages. On the assumption that animals are chosen first at random, the expected total number of first choices for each animal is 6. A chi-squared test on the data in table 2 gives $\chi^2 = 14.0$, 5df, $0.01 < p < 0.025$ which indicates that animals are not chosen first at random. The crab is chosen almost twice as often as chance would predict, the stag beetle three times less often and the gecko six times less often. We hesitate to suggest an explanation for these specific findings but the crab was a large one (table 2) and is almost archetypically familiar whereas the gecko and stag beetle were the two smallest specimens and are less familiar.

Table 3 shows how often each animal was chosen second, third, fourth, fifth and sixth. Using the data from tables 2 and 3, we can obtain for each animal its mean position and a standard error of this mean. These values are shown in table 4. Had an animal always been chosen first, its mean position would be 1.0. Had it been

chosen randomly, its mean position would be 3.5. To see whether there are any significant differences between the mean positions of the six animals, a Tukey-Kramer test was used and values of q calculated for k = 6, df = 210. These show that the only two significant differences at the 5% level are that the crab is chosen earlier than both the gecko (q = 4.27) and the armadillo (q = 4.17).

Reasons given by pupils for naming animals as they did

For each animal, pupils were asked what its name was and why they had named it as they had. Overall 93% of the presented specimens (n = 216; 6 animals to each of 36 pupils) elicited a name (e.g. 'Armadillo' or 'I'm not really sure, is it a stoat?') or category (e.g. 'It's definitely a bird, but I don't know which sort' for the starling). The remaining 7% of presentations resulted in 'Don't know' or an equivalent.

The reasons given by pupils as to why they had named each animal as they had were categorised as 'Anatomy', 'Behaviour' or 'Habitat'. For example, the following response by a 14 year-old girl presented with the stoat (which, as shown in figure 2, was in its winter coat) was categorised as 'Anatomy': 'I've seen it before and read up on them. I can tell it's not a weasel. It has a black tip to its tail and weasels don't go white in winter'. The following response, by an 8 year-old girl, was categorised both as 'Behaviour' ['they clip you' and 'make it run fast'] and 'Anatomy' ['These bits there' and 'the legs']: 'These bits there [points to pincers] they clip you and the legs make it run fast'. The following response by a 5 year-old boy to the stoat was categorised as 'Habitat': 'It lives in the snow'. Table 5 shows the number and percentage for each age class of responses. A total of 216 animal presentations were made but the total number of responses exceeds 216 as some pupil responses fell into two response categories.

Table 5 clearly indicates that the great majority of pupils give anatomical reasons (87%) rather than behavioural reasons (10%) or reasons based on habitat (3%) for naming the specimens. There is no significant evidence that different age groups differ in the reasons they use, though there is a hint that older (14 year-old) pupils are more likely to use habitat as a reason.

After a pupil had given a reason as to why the animal was an X (e.g. why the presented starling was a blackbird if the pupil had named it a blackbird), the pupil was asked what it was about X that made it an X (e.g. 'What is it about it that makes it a blackbird?'). This was to investigate in more depth the attributes used by pupils when identifying animals. As before, responses were classified as 'Anatomy', 'Behaviour' or Habitat'. These are recorded in table 6. Again, anatomical reasons predominate. However, reasons based on behaviour and habitat are more important than when simply explaining why an X is an X (table 5). Further, there is more evidence now that older pupils are less likely to rely solely on anatomical criteria.

Differences between girls and boys in their responses to the question 'Why is the animal an X?' are shown in table 7. The one significant difference is that girls are

1.8 times more likely than boys than boys to refer to features of the head such as the face, eyes or ears.

The sources of pupil knowledge

Pupils who suggested a name for an animal were asked where they had learnt that name. The first row in table 8 shows the number of times pupils of different ages were able to state where they had learnt the name in question. Overall, 85% of the presented animals resulted in pupils being able to state where they had learnt the name in question. As one might expect, the 5 year-old children were less able to do this (57%) than the older pupils (94%) though the χ^2 across the four age categories is not quite significant (as indicated in the last column of the first row of table 8).

Pupil responses were then categorised into 'From home', 'From school', 'From direct observation', 'From TV/video/CD' and 'From book'. The numbers of responses in these five categories are shown in table 8 as a function of the age of the pupil. Perhaps the most notable conclusion to draw from table 8, aside from the obvious effect that age has, is the infrequency with which schools and books are mentioned as sources of knowledge. Overall the order of importance is: home, direct observation, TV/video/CD, school, books.

This conclusion is reinforced by table 9. Here, pupils were asked where they had learnt the attributes that they stated were necessary for category membership. For example, suppose a pupil stated that the stag beetle was an insect because it has six legs. He or she would then be asked 'How do you know that?' and their answer categorised, as in table 8, into one of the five categories shown in table 9. Again, the results show that the most important source of learning is the home and the least are school and books.

Differences between the sources of their learning for girls and boys are shown in tables 10 and 11. Table 10 shows whether girls and boys have different sources of learning for the names they gave to the animals. The one significant difference is that boys are 2.5 times more likely to state that they have learnt from books than are girls. Table 11 shows whether girls and boys have different sources of learning for the attributes they state are necessary for category membership. Again, the one significant difference is that boys are 2.6 times as likely to state that they have learnt from books than are girls.

How pupils grouped the animals

The number of groups into which pupils of different ages grouped the animals is shown in table 12. It seem that the older pupils were more likely to group the animals into a small number of groups, though, strictly speaking, the differences are not quite significant (a t-test comparing the mean number of groups for 5 and 14 year-olds gives $t = 1.87$, $df = 16$ which is significant at the 5% level on a one-tailed but not on a two-tailed test).

Pupils were asked their reasons for grouping the animals as they did and their responses are summarised in table 13. The youngest pupils relied mainly on anatomical reasons. Older pupils still used anatomical differences but were more likely also to use other reasons, such as those based on taxonomy (e.g. 'It is a mammal: it has hair'), habitat (e.g. ' ... not a land animal, a sky animal') and behaviour. They were less likely than younger pupils simply to state that some animals could not be grouped together because they were 'different'. Girls and boys differ in the reasons they give (table 14) with girls using a richer variety of explanations than boys who largely rely on anatomical considerations alone.

Discussion

When presented with an animal specimen and asked to name it and to say what features it possesses that are salient to them in naming it, children have to recall their existing mental model of 'closest fit' and match that to the animal they see in front of them. In this study, striking features such as the carapace of the crab, the wings , beak and claws of the starling, the bony scutes which form the 'armour' of the armadillo, the tail, face and colour of the stoat, the tail, skin and toes of the gecko and the mandibles of the stag beetle were all important. Overall, anatomical features were cited far more often than behavioural or habitat features. Some pupils linked anatomical features to where the animals lived and to certain behaviours it must show.

The fact that so few pupils used any knowledge about the habitats in which the animals naturally occur possibly reflects the emphasis in much of science teaching on naming and categorising organisms as isolated entities. An alternative approach would be for a teacher to start with environments and their significant features and then explore with pupils how organisms in those environment are adapted both anatomically and behaviourally to their particular habitats. Other research has suggested that few pupils have such an integrated understanding of environments (Brody 1994, Strommen 1995).

Schools and books were less important as sources of knowledge than the home and direct observation, even though this was a study carried out in school classrooms. This is perhaps disheartening for a science educator interested in the promotion of learning by schools. On the other hand, it is encouraging that extra-school activities are still an important source of knowledge. The relative unimportance of schools as sources of learning in this area is probably a reflection, at least in part, of the fact that little profitable time seems nowadays to be spent in primary and secondary schools in England and Wales on direct observations of animals (Lock, Kaye and Mason 1995, Reiss 1996). Schools could, of course, play a far more significant role in this area, building upon the knowledge children acquire outside school (e.g. Inagaki 1990, Solomon 1994).

Some of the gender differences are interesting. Girls were more likely than boys to comment on features of the animals' faces which suggests that girls are perhaps more likely to show empathy than boys. Boys, on the other hand, were more likely than girls to cite books as sources of knowledge. This fits in with the fairly

widespread finding that whereas overall girls read more than boys, boys read non-fiction more than girls (e.g. Hall and Coles 1997). As one might hypothesise, girls show a richer variety of strategies for grouping the animals, the boys tending to depend simply on anatomical features.

We would like tentatively to suggest that as pupils age, they pass through a number of levels with regard to the reasons they use for grouping animals. These ages and levels, with examples, are outlined in table 15. Children move from regarding each organism in isolation through recognising shared anatomical features to recognising attributes connected with behaviours and habitats. Older pupils also recognise the embedded knowledge of hierarchical taxonomies - e.g. they know at least some of the reasons why an animal is a bird.

Finally, what emphases there are within science curricula on naming and classifying organisms may be at the expense of environmental understanding, which gives rise to concern. As science educators, we need to teach pupils to become scientifically and environmental literate citizens. We don't want pupils to have a model of the environment simply as a background against which individual organisms stand. Rather, we want pupils to understand the ways in which animals and other species affect and are affected by their environments. We need to look at current emphases within school curricula. Alongside mental models of animals, pupils need mental models of a range of environments and an appreciation of how these environments meet the needs of the organisms that are adapted to live within them.

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Appendix A. Methodology for this and related projects

1. Researcher should note the binomial name, common name and the lengths of the two maximum dimensions (to the nearest cm) of each specimen used. (Dimensions must be at right angles to one another.)

2. Researcher has six animals on a table / floor in the corner of a classroom. Each animal is stuffed / freeze-dried / equivalent (must not smell, must be dry to the touch, must be in good condition). One animal from each of the following six groups:

- common, non-primate, native, wild mammal - e.g. (in the UK) stoat, squirrel, hare, hedgehog, fox
- non-primate, non-native, wild mammal - e.g. (in the UK) armadillo, chipmunk, mongoose, wombat
- common bird - e.g. (in the UK) starling, thrush, robin, crow, great tit
- reptile - e.g. gecko, lizard, snake, tortoise
- common aquatic invertebrate [but not an insect] with an exoskeleton - e.g. crab, sea urchin, crayfish
- common large insect - e.g. (in the UK) stag beetle, grasshopper, butterfly, bumble bee.

3. Pupils go individually to the researcher while the rest of the class continue with their normal classroom teacher.

4. Researcher tells pupil (s)he would like to ask her/him some questions about these animals.

5. Researcher asks pupil her/his name and age (in years). [All answers recorded by researcher in writing on checksheet which is kept out of sight of the pupil - see Appendix C. Researcher also records gender of pupil, date and name of school.]

6. Researcher asks pupil to choose the order for the six animals in which she/he would like to talk about them. [Order recorded by researcher.]

7. For each animal in turn, researcher asks pupil 'Could you please tell me what this is?'. [Prompt may be needed - e.g. 'What do we call it? / What is it called?' if pupil says 'Don't know'. If response is 'Animal' this is probed by 'What kind of animal?'.]

8. After naming, for each animal in turn, researcher asks pupil 'Why do you call it an X [pupil response to previous question]?' or 'How did you recognise the X as an X?'.

9. Researcher asks 'How do you know that?'.

10. For each animal in turn, researcher asks pupil 'What is it about it that makes it an X?'.

11. Researcher asks 'How do you know that?'.

12. After these questions have been asked of all six animals, researcher asks pupil 'Would you group the animals for me, please? Do any of them belong together?'. [Researcher records composition of groups.]

13. Finally, researcher asks of each group of animals 'Why do these go together?'.

14. Researcher thanks pupil. Tells her/him 'You may see me again next year' and makes any further notes about the interview before going on to the next pupil.

15. Subsequently, out of sight of the pupils, researcher asks teacher to classify each pupil into 'above average ability', 'average ability' and 'below average ability'. If teacher asks whether researcher means specifically in science or generally, researcher replies generally / overall.

Appendix B. Part of the checksheet. [Only the first (general) section, the section for recording answers relating to just the first animal and the final (grouping) section are shown. In reality, the checksheet needs to accommodate answers relating to all six animals and so is at least two sides of A4 in length.]

OBSERVATION SHEET MENTAL MODELS OF ANIMALS

Date School Pupil Age Gender Attainment

Order animals chosen
1 = 2 = 3 = 4= 5= 6=

Animal 1
Could you please tell me what this is?
? prompt

Why do you call it an X?

How do you know that?

What is it about it that makes it an X?

How do you know that?

FIVE MORE SECTIONS SIMILAR TO ABOVE

Grouping
Why do these go together?

Other observations
e.g. context of pupil's work at time

Appendix C. Rationale for the research.

1. Use of stuffed animals is more realistic than the use of drawings or photographs. Presentation of the animals is more controllable by the researcher(s) than if live animals are used.

2. Can be used with pupils / students of a wide range of ages (4 years upwards).

3. Allows longitudinal study (e.g. each pupil can be interviewed every year) using either the same or different animals.

4, Allows cross-sectional study using the same animals for different age groups.

5. Allows other researchers to use the protocol (e.g. in other countries) without requiring audio/video-taping equipment. [Any researcher intending to use the approach described here is very welcome to send their pilot results to us for comment and evaluation. We are also very willing to send out a master checksheet for photocopying.]

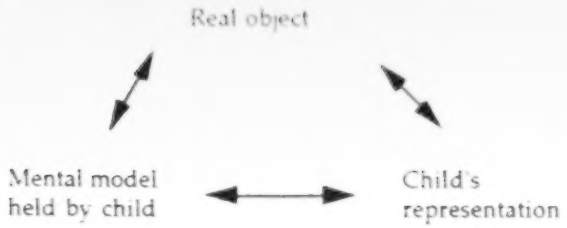

Figure 1. Relationship between the real object, the mental model held by the child and the child's representation.

Figure 2. One of the pupil's interviewed together with the six experimental animals.

Table 1. Specimens used in the study.

Common name	*Binomial name*	*Dimensions (two longest orthogonal axes in cm)*
Stag beetle	*Lucanus cervus*	8 x 5
Edible crab	*Cancer pagurus*	14 x 10
Common house gecko	*Gehyra mutilata*	7 x 7
European starling	*Sturnus vulgaris*	17 x 11
Common long-nosed armadillo	*Dasypus novemcinctus*	53 x 15
Stoat	*Mustela erminea*	31 x 9

Table 2. Identity of animal chosen first by pupils of different ages.

Animal	5 years	8 years	10 years	14 years	Total (n=36)
Stag beetle	2	0	0	0	2
Crab	2	4	4	3	13
Gecko	0	0	1	0	1
Starling	3	3	2	0	8
Armadillo	1	1	1	4	7
Stoat	1	1	1	2	5

Table 3. Identities of animals chosen second, third, fourth, fifth and sixth by pupils of different ages.

Second choice	5 years	8 years	10 years	14 years	Total (n=36)
Stag beetle	1	1	4	1	7
Crab	1	2	2	1	6
Gecko	1	1	1	2	5
Starling	2	2	0	3	7
Armadillo	3	1	0	0	4
Stoat	1	2	2	2	7
Third choice	**5 years**	**8 years**	**10 years**	**14 years**	**Total (n=36)**
Stag beetle	0	5	1	1	7
Crab	2	2	0	1	5
Gecko	3	1	0	3	7
Starling	1	1	2	2	6
Armadillo	1	0	4	0	5
Stoat	2	0	2	2	6
Fourth choice	**5 years**	**8 years**	**10 years**	**14 years**	**Total (n=36)**
Stag beetle	1	2	0	5	8
Crab	2	1	1	1	5

Gecko	4	3	3	1	11
Starling	1	2	2	0	5
Armadillo	0	0	2	0	2
Stoat	1	1	1	2	5
Fifth choice	5 years	8 years	10 years	14 years	Total (n=36)
Stag beetle	3	0	2	1	6
Crab	1	0	1	2	4
Gecko	1	2	2	2	7
Starling	0	0	0	4	4
Armadillo	1	4	1	0	6
Stoat	3	3	3	0	9
Sixth choice	5 years	8 years	10 years	14 years	Total (n=36)
Stag beetle	2	1	2	1	6
Crab	1	0	1	1	3
Gecko	0	2	2	1	5
Starling	2	1	3	0	6
Armadillo	3	3	1	5	12
Stoat	1	2	0	1	4

Table 4. The mean position in which each animal was chosen and the standard error of this mean.

Animal	*Mean*	*Standard error of the mean*
Crab	2.72	0.29
Starling	3.22	0.30
Stoat	3.50	0.28
Stag beetle	3.75	0.25
Armadillo	3.89	0.33
Gecko	3.92	0.22

Table 5. Reasons used by pupils for naming each specimen as they did.

Reasons used	5 years n (%)	8 years n (%)	10 years n (%)	14 years n (%)	Total n = 231
Anatomy	46 (85%)	50 (91%)	54 (96%)	52 (79%)	202 (87%)
Behaviour	7 (13%)	5 (9%)	1 (2%)	9 (14%)	22 (10%)
Habitat	1 (2%)	0 (0%)	1 (2%)	5 (8%)	7 (3%)

Table 6. Reasons used by pupils as to why each specimen is what they said it is.

Reasons used	5 years n (%)	8 years n (%)	10 years n (%)	14 years n (%)	Total n = 264
Anatomy	43 (80%)	52 (88%)	53 (71%)	54 (71%)	202 (77%)
Behaviour	9 (17%)	6 (10%)	17 (23%)	17 (22%)	49 (19%)
Habitat	2 (4%)	1 (2%)	5 (7%)	5 (7%)	13 (5%)

Table 7. Reasons used by girls and boys as to why each specimen is what they said it is.

Reasons used	Boys n = 108	Girls n = 108	χ^2 (1df)
Anatomy	100	102	0.02
body	90	74	1.56
disrupters	75	75	0
distinctive	58	58	0
head	30	53	6.37*
Behaviour	24	25	0.02
Habitat	8	5	0.69

* $p < 0.05$.

Table 8. The sources of learning of the names of the animals shown by age groups.

Whether name was learnt and where	5 years n (%)	8 years n (%)	10 years n (%)	14 years n (%)	Total n = 216	χ^2 (3df)
Learnt name	31 (57%)	48 (89%)	51 (94%)	53 (98%)	183 (85%)	6.62
From home	14 (45%)	33 (69%)	29 (57%)	39 (74%)	115 (63%)	11.9**
From school	2 (6%)	6 (13%)	10 (20%)	13 (25%)	31 (17%)	8.87*
From direct observation	10 (28%)	8 (17%)	17 (33%)	20 (38%)	55 (30%)	7.04
From TV/video/CD	7 (19%)	7 (15%)	13 (25%)	18 (34%)	45 (25%)	2.84
From book	0 (0%)	7 (15%)	9 (18%)	12 (23%)	28 (15%)	11.1*

* $p < 0.05$.
** $p < 0.01$.

Table 9. The sources of learning of the attributes necessary for category membership shown by age groups.

Whether attributes were learnt and where	5 years n (%)	8 years n (%)	10 years n (%)	14 years n (%)	Total n = 216	χ^2 (3df)
Learnt attributes	35 (65%)	46 (85%)	52 (96%)	54 (100%)	187 (87%)	4.68
From home	10 (29%)	28 (61%)	23 (44%)	34 (63%)	95 (51%)	13.2***
From school	4 (11%)	5 (11%)	9 (17%)	17 (32%)	31 (17%)	12.0**
From direct observation	6 (17%)	8 (17%)	13 (25%)	17 (32%)	44 (24%)	6.73
From TV/video/CD	13 (37%)	8 (17%)	14 (27%)	12 (22%)	50 (27%)	1.77
From book	0 (0%)	6 (13%)	13 (25%)	10 (19%)	29 (16%)	13.5***

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.005$.

Table 10. The sources of learning of the names of the animals for girls and boys.

Whether name was learnt and where	Girls n = 108	Boys n = 108	χ^2 (1df)
Learnt name	89	94	0.14
From home	55	60	0.22
From school	14	17	0.29
From direct observation	24	31	0.89
From TV/video/CD	20	25	0.56
From book	8	20	5.14*

* $p < 0.05$.

Table 11. The sources of learning that girls and boys state are necessary for category membership.

Whether name was learnt and where	Girls n = 108	Boys n = 108	χ^2 (1df)
Learnt name	96	91	0.13
From home	44	51	0.52
From school	16	19	0.26
From direct observation	27	23	0.32
From TV/video/CD	21	23	0.09
From book	8	21	5.83*

* $p < 0.05$.

Table 12. The number of groups into which pupils of different ages grouped the animals.

Number of pupils with this number of groups	5 years n = 9	8 years n = 10‡	10 years n = 9	14 years n = 9
1	0	0	0	0
2	1	1	0	1
3	1	3	2	3
4	1	2	2	3
5	2	0	4	2
6	4	4	1	0
Mean	4.78	4.3	4.44	3.67
Standard error	0.49	0.50	0.37	0.33

‡ One 8 year-old girl suggested two different ways in which the animals could be grouped.

Table 13. The reasons given by pupils for of different ages for grouping specimens.

Reasons given for grouping	5 years	8 years	10 years	14 years	Total n = 56
Anatomy	4	4	6	4	18
Taxonomy	0	2	3	4	9
Habitat	0	0	3	2	5

Non-possession of a feature	1	1	2	1	5
Behaviour	0	1	1	2	4
Different	3	3	1	1	8
Other	2	2	2	1	7

Table 14 The reasons given by boys and girls for grouping specimens.

Reasons given for grouping	Girls' responses n (%)	Boys' responses n (%)
Anatomy	7 (22)	11 (46)
Taxonomy	6 (19)	3 (13)
Habitat	3 (9)	2 (8)
Non-possession of a feature	3 (9)	2 (8)
Behaviour	3 (9)	1 (4)
Different	4 (13)	4 (17)
Other	6 (19)	1 (4)

Table 15. Proposed levels in the reasons used by children of different ages for grouping animals.

Level	Criteria	Examples of comments	Typical age range
Level 0	Isolated units - all animals are different, hence must be kept separate.	'Keep them apart so they don't get mixed up'. 'They stay apart, they are different'.	5 to 7 years
Level 1	Anatomy. Often the single possession of a feature.	'That's the only one with scales'.	8 to 10 years
Level 2	Habitat and/or behaviour as well as anatomy.	'It's a sea animal'. 'They live in woodland'.	11 to 14 years
Level 3	Formal hierarchical knowledge of taxonomy.	'It is a bird because it has feathers'.	14+ years